able strength. Furthermore, the shower covers, at any instant, only a rather limited region because the air obviously can not be going up everywhere at the same time over a wide area. Hence also it is of short duration. A persistent rain of largish drops can happen only where the cause of the convection, such as a mountain across the path of the wind, is enduring and fixed in position. But such a rain is not a shower.

So much for the difference between the ways in which drizzles and showers are formed. It will be interesting now to inquire what circumstances lead to vertical convections of the air such as give showers, and what to drizzle rains in which clearly there is but little or no convection. Whether or not marked convection will develop depends on the vertical distribution of temperature, mainly, and to some extent also on that of water vapor, for increase of humidity decreases the density of the air just as does increase of temperature. Convection not only can, but must, ensue wherever and whenever the surface of the earth is considerably warmed (by sunshine chiefly) since it in turn then correspondingly heats the lower air which thereupon expands and becomes lighter. This is the origin of the heat thunderstorm so common in the Tropics and adjacent regions. Where condensation occurs in such cases latent heat of vaporization is rendered sensible and the convection thereby still further accentuated, as is evident from the great height to which the cumulus cloud often towers.

Another way by which the vertical contrast of temperature essential to convection is established is by the importation of colder air above. Still another is the wedging in of cold air under warm air. Both of these ways, overrunning and underrunning, occur along the cold front, or windshift line, and often in such vigorous manner as to produce severe squalls. Still another way of inducing vertical convection, commonly moderate and therefore productive usually of rather gentle showers, is by the gradual heating of the under layer or portion of cool air as it drifts over a surface that becomes increasingly warm with the distance traveled. This applies perfectly to a broad deep mass of air of polar origin drifting equatorward over an ocean. Here, and often on land as well, the showers are indicative of the origin (polar) of the air in which they are occurring.

On the other hand, the lower portion of a current of air of tropical origin moving over the ocean, say, or land either, to higher latitudes, tends to become progressively colder and colder, and thereby so stable that local convection in it is quite impossible. After a time the dew point may be passed with the formation of fog and low cloud out of which a drizzle, light to heavy, may fall, but never a shower, there being no vertical convection, except that small amount incident to the turbulence caused by surface friction.

We therefore are assured that such rains as occur within polar air as it advances equatorward are quite likely to be of the shower type and, conversely, that showers often are convincing evidence that the passing air is of polar origin. Similarly, tropical air moving poleward may afford a drizzle long before a mountain, or a barrier of cold air, is encountered. Also a drizzle is evidence of tropical air on its way to higher latitudes.

Showers evidence the presence of marked vertical convection; drizzle proves the absence of such convection. Showers often indicate the equatorward passing of polar air; drizzle the presence of poleward-moving tropical air. Thus shower and drizzle are well nigh rain extremes—in size of drops, rate of precipitation, nature of origin, and their meteorological significance.

METEOROLOGY AND THE FOREST FIRE PROBLEM

By S. B. SHOW

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Foresters have always recognized the importance of the relationship between weather and forest fires in the West. For a number of years after organized fire suppression was instituted, the relative importance of the various weather factors upon fire suppression during the fire season was unknown, or at best, guessed at. Even in these early days it was generally recognized that occasionally in every fire season there occurred short periods of one or several days when the forest cover was unusually inflammable and at times seemed almost explosive. These periods frequently produced greater damage, burned over area, and suppression costs than the remaining 95 per cent of the fire season. This being so, it was essential that attempts be made to determine the factors that brought about these dangerous periods. It was recognized, of course, that abnormal weather conditions were responsible for these periods, but which of the meteorological conditions were most responsible was unknown to foresters. Obviously, the study of the influencing factors was the first needed step to be undertaken in the solution of this problem.

Accordingly, from 1915 to 1925 this phase of the problem was the subject of several independent studies by various members of the Forest Service in the important fire regions, aiming to supplement the work of the Weather Bureau. The main objective was the determination of the principal climatic causes of the sudden changes in the inflammability of forest fuels.

It was found that during the fire season, for some of the most inflammable of our forest types, wind velocity and direction and relative humidity are the most important meteorological factors affecting the spread of a fire. With wind remaining the same, relative humidity is an exceedingly important factor in controlling the size of fires; the lower the humidity, the greater the size. Similarly, with relative humidity constant, there is an increase in size of fires as the wind velocity increases. The critical periods of explosive inflammability always occur when very low relative humidity occurs together with a high wind velocity. Neither low relative humidity nor high wind velocity alone has resulted in such a high rate of spread as the combination of these two factors. The effect of changes in wind direction on fire control endeavor is obvious.

The prediction of these periods and of their duration is of utmost importance to those engaged in forest fire control. The Weather Bureau began its fire-weather warning service in 1916 in California, and has, year by year, consistently enlarged and improved this service. In 1926 a special fire weather official was assigned to the California district which coincides with Region 5 of the Forest Service. Since that time substantial progress has been made in laying the ground work for systematic fire weather forecasting and increasingly valuable information has been furnished the field officers of the protection agencies. Many special observation points are

now supplied with instruments, owned and installed by the Weather Bureau. Most of these special stations are either ranger headquarters or forest lookout stations, and the forest personnel act as observers.

The fire-weather forecasting service furnished in California can be divided broadly into two classes, one of these services being the telegraphic general fire warning forecasts which are sent out in advance of dangerous fire weather or anticipated lightning storms. These messages emanate from the San Francisco office of the Weather Bureau and are sent to designated fire-fighting agencies in those parts of the State affected. For convenience in this work the Weather Bureau has divided the State into 11 forecasting areas, designated by locality, such as North Coast, Siskiyou, Plateau, North Sierra, etc. The field personnel of the Forest Service have learned from experience to depend upon the reliability of these warnings. When one of these messages is received the tendency is for each man to be more alert; the lookout scans the country more closely, the fireman is on the qui vive, the fire dispatcher makes doubly certain of his sources of man power and equipment, the Ranger stays in closer touch with his protective organization. If a fire warning message comes over a week-end or holiday, often emergency men are hired as an additional preventive measure. If these messages come during the time a fire is burning, very often plans are changed accordingly, especially if the fire is not yet under control. These fire warnings are a very important aid in our fire control.

While such general, more or less broadcast warnings were of value, the need was apparent for more localized forecasts. Such a need is particularly great where there are large going fires. Accordingly, in 1929, through a cooperative agreement between the State, Weather Bureau, and the Forest Service, a portable forecasting unit was set up. This unit consisted of a truck, completely equipped with meteorological instruments and a radio receiving set. The fire weather official was in charge of the unit and had, as an assistant, a radio operator. This unit operated in 1929 and 1930, and is on the job again this season. It is scheduled to visit every national forest throughout the State each season, as well as spending a proportionate amount of time in each State fire district. Contacts are made with Forest Service and State personnel and weather stations maintained by these agencies are checked and inspected. Daily forecasts are made from weather information received over the radio and through observation made by the fire weather officials. These forecasts are made for the locality in which the truck is stationed at the time. A central dispatching agency at the regional Forest Service office is kept informed of the location of the unit at all times, and it is dispatched whenever practicable to going fires anywhere in California.

So far, there have not been as many opportunities as was originally expected to make use of the unit on going fires. On those accasions, however, when forecasts have been given on going fires, the reports from the field as to its value have been most encouraging. For example, on one very large fire, in very inaccessible country, due to forecasts of favorable weather conditions for the following day, an order for a large number of men and additional supplies and equipment was canceled, and the Government saved a very considerable sum of money. Certainly, the value of localized fire warning service has been demonstrated through the performance of this portable forecasting unit. An extension of this localized service, together with a continuance of the constantly improving general fire weather warning forecasts, offers a major opportunity for improving systematic fire protection in California.

THE PROBABLE VALUES OF SEASONAL RAINFALL IN LOS ANGELES FROM 1850 TO 1877

By CHARLES C. CONROY

[Author's Abstract]

Some years ago the writer began to collect material bearing upon the rainfall of the Los Angeles area prior to the establishment of the United States Signal Service office in that city on July 1, 1877. This material was found in private journals and diaries, in printed accounts, and, after 1854, in the files of Los Angeles newspapers. These last yielded an abundance of information, and the author was finally enabled to discover practically every day on which rain had fallen over the entire period.

These daily statements were translated into numerical values by comparison with estimates based upon Weather Bureau measurements of rainfall for similarly described days after July 1, 1877. For example, it was found that days on which rain was said to have fallen steadily but not heavily throughout the day, when checked by the measurements, had an average precipitation of 1.32 inches. Using this method for other descriptions, it was possible to build up a table of daily estimates for the entire period 1850–1877. Monthly and seasonal results followed as a matter of course.

The conclusions were then checked by reference to the recorded measurements of rainfall at San Francisco and San Diego for the same period, a ratio having been worked out for two 10-year periods—one dry and one wet—from the records of all three stations subsequent to July 1, 1877. The use of this method of checking required great care, since there was sometimes an inversion of monthly or even seasonal values, San Diego receiving more rain than San Francisco. Fortunately the local accounts prior to 1877 were in almost all cases so definite that estimates could be made with considerable assurance of their approximate accuracy.

Further checking was done for the period 1871–1877 through comparisons of daily barometric readings at San Francisco and San Diego. For this same period a series of measurements made at Los Angeles by proper exposure of a gage was also found, as were also similar measurements for a single year in the fifties.

No rigid mathematical investigation was possible by these means, but it is believed that the evaluated amounts have a margin of error under 15 per cent.

Since the results cover 27 years, the subsequent records of the Los Angeles Weather Bureau office from 1877 to date may be divided exactly into two equal periods.